Tetiaroa Society FP

2023 Impact Report

Note from the President

Dear Reader,

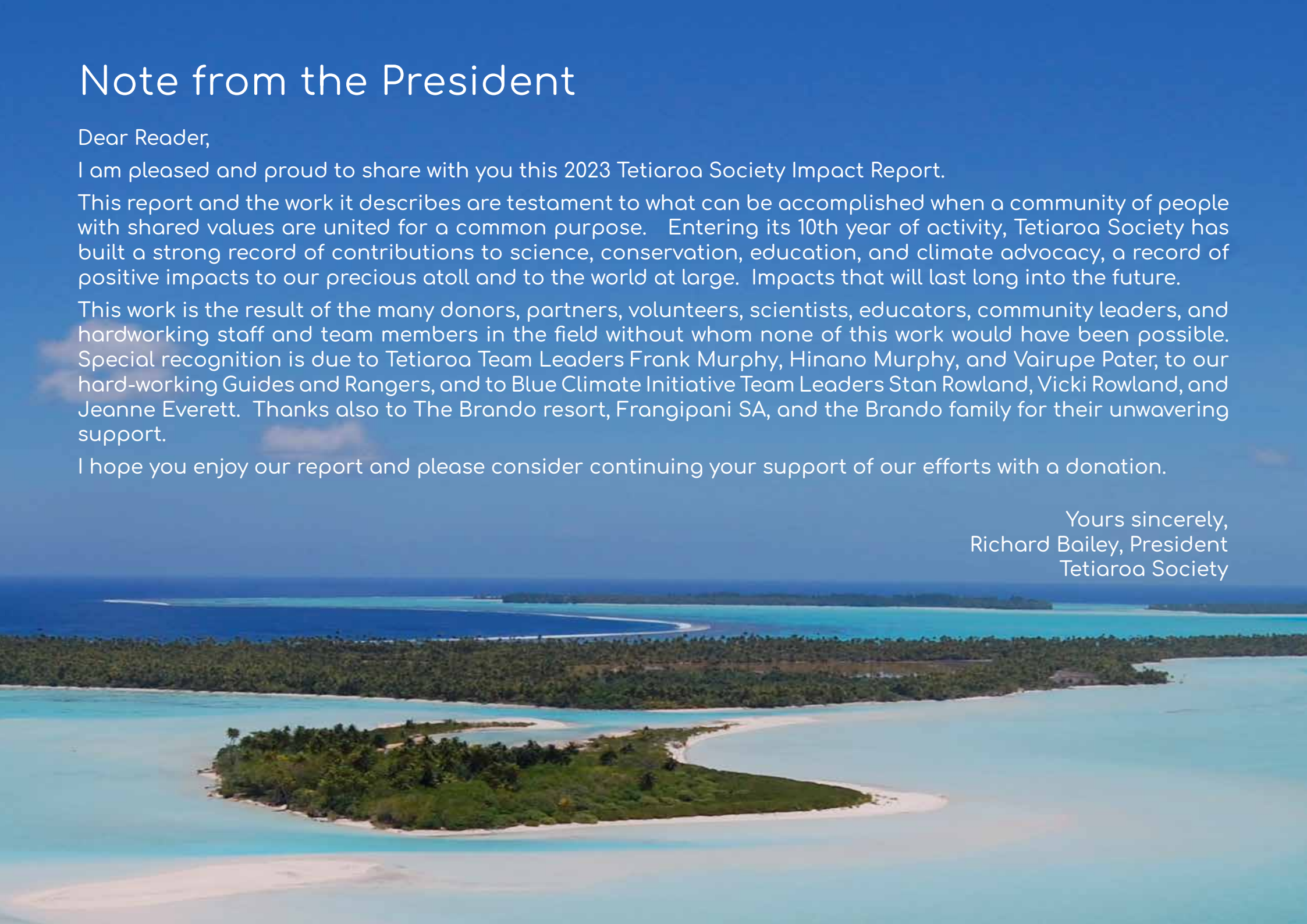
I am pleased and proud to share with you this 2023 Tetiaroa Society Impact Report.

This report and the work it describes are testament to what can be accomplished when a community of people with shared values are united for a common purpose. Entering its 10th year of activity, Tetiaroa Society has built a strong record of contributions to science, conservation, education, and climate advocacy, a record of positive impacts to our precious atoll and to the world at large. Impacts that will last long into the future.

This work is the result of the many donors, partners, volunteers, scientists, educators, community leaders, and hardworking staff and team members in the field without whom none of this work would have been possible. Special recognition is due to Tetiaroa Team Leaders Frank Murphy, Hinano Murphy, and Vairupe Pater, to our hard-working Guides and Rangers, and to Blue Climate Initiative Team Leaders Stan Rowland, Vicki Rowland, and Jeanne Everett. Thanks also to The Brando resort, Frangipani SA, and the Brando family for their unwavering support.

I hope you enjoy our report and please consider continuing your support of our efforts with a donation.

Yours sincerely,
Richard Bailey, President
Tetiaroa Society



We are very pleased to share Tetiaroa Society's 2023 Impact Report

This year was a very busy one for Tetiaroa Society, with growth being the main theme. This is reflected in the extra pages in this Impact Report and in the new faces working as part of our extended team. The Guide team were once again the face of Tetiaroa Society at The Brando and created once-in-a-lifetime experiences for the guests while teaching them about island conservation at the same time. The Rangers worked as hard as ever patrolling the island, moving researchers and students around the island, assisting scientists in the field, and managing the Ecostation.

Efforts to understand and care for the island of Tetiaroa fill the following pages. These efforts came from researchers, students, volunteers, interns, community members, staff of The Brando, and of course the staff of the Tetiaroa Society. If we could gather this Tetiaroa family together, and record their stories from just this last year, it would fill a decent-sized book. It would tell about adventures, and hardships, and glorious mornings on the lagoon. You would hear marvelous descriptions of insects, and fish behavior, and laments about coral cuts, and mosquito bites, and sunburn. The school kids would tell you about what they learned about the island and how we take care of it. The volunteers would tell you about teamwork and the joy of contributing to our shared conservation goals.

This report can't tell all those stories. But we can give you an idea of what is going on here, and how the work of Tetiaroa Society, intertwined with the Brando family trust, The Brando Resort, and the community of Arue is developing a model of island sustainability that is now being recognized globally.

Enjoy the report...

Contents

RESEARCH & CONSERVATION

Almost all of the research being done on Tetiaroa now falls under the umbrella of the Tetiaroa Atoll Restoration Program (TARP). Technically this would include any research that is recording the response to our conservation actions which remove invasive species. These include changes in population dynamics and behavior of organisms, changes in the physical and chemical environment, and the arrival of new breeding species.

After effectively removing rats from the atoll in 2022, our next major conservation action which took place this year, was to remove Yellow Crazy Ants. This program eliminated another dangerous invasive species and was an important step towards our goal of restoring the natural environment of the island. On cue field observations and data began to show the recovery of the island ecosystems. Since this was the first year of post eradication studies, our research teams have been busy collecting and analyzing data. We expect a long list of scientific publications in coming years that will tell the story of how the biological and physical systems of an atoll recover.

Rat Eradication

Principal Investigators:
Baudouin des Monstiers,
Richard Griffiths, Frank Murphy
Affiliation:
Island Conservation
Tetiaroa Society
Project Dates: 2018 - ongoing

We will continue this work into 2024, when we expect to make the whole of Tetiaroa totally rat free.

In 2018 Tetiaroa Society and Island Conservation carried out a successful rat eradication on Motu Reiono. Then in 2020 another eradication was done on Motu Onetahi and Honuea. In 2022 an attempt was made at eradication across all the remaining motu. Unfortunately, in follow up field work rats were detected in small numbers on some of the motu. A decision was made at that point to create a team that would work to detect rats and then eliminate them motu by motu. This work spanned all of 2023 and, although it has gone slowly, there has been a marked reduction in numbers and some of the remaining motu are now rat free. We will continue this work into 2024, when we expect to make the whole of Tetiarao totally rat free. Note that after the large operation in mid-2022 the numbers of rats have been so small that the island ecosystem has essentially been rat free. You will hear about the effect of this in other TARP projects.

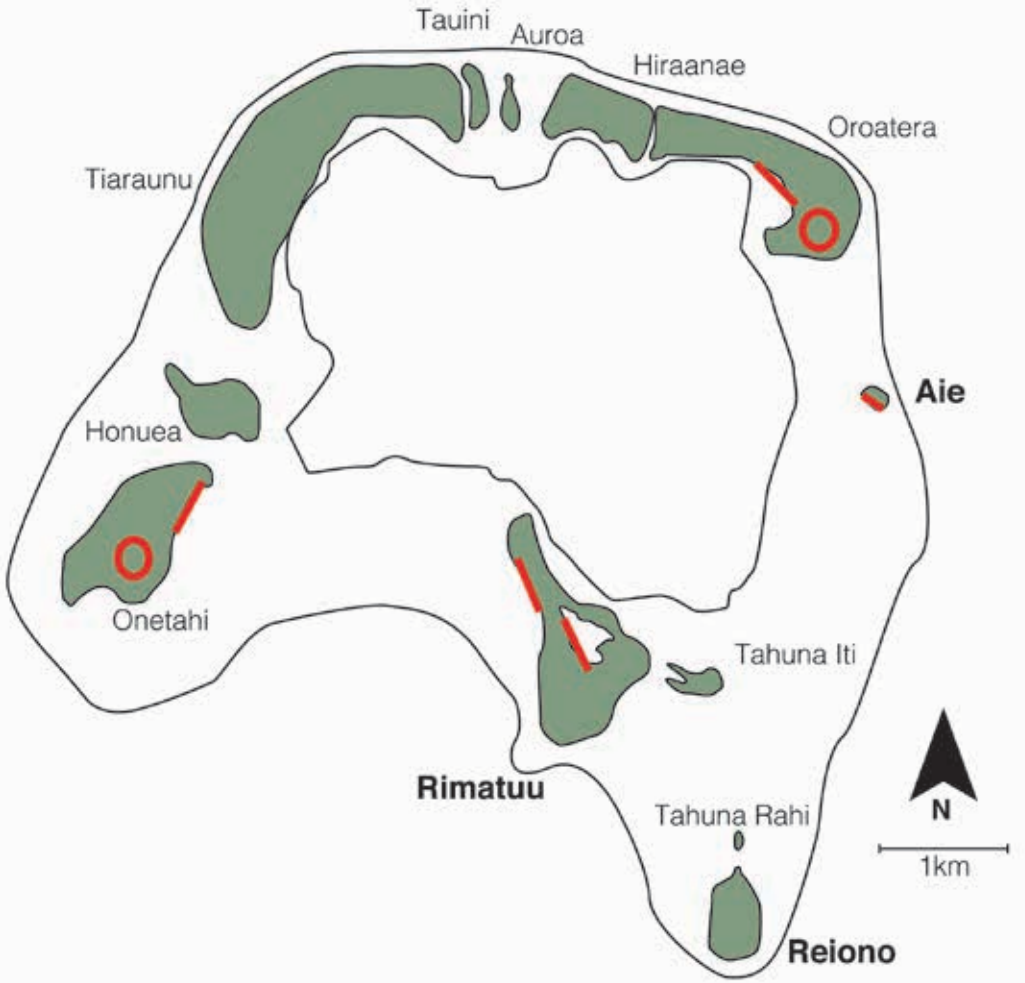
Using eDNA for Rat Detection

Principal Investigators:
James Russell, Sebastian Steibl
Affiliation:
University of Auckland
Project Dates: June 2022 – August 2023

The use of environmental DNA (eDNA) might be a powerful new tool to inform and accelerate decision-making in island restoration management.

Rapid, reliable, and cost-efficient assessments of the invasion status of islands is key to accelerate restoration efforts and responses to potential re-invaders or survivors of an attempted eradication. We used the Tetiaroa rat and YCA eradication operations to assess the capabilities and limits of eDNA in an applied real-world island management scenario for the first time. In 2023, we conducted the third sampling campaign on four motus of Tetiaroa atoll to analyse eDNA occurrence and concentrations one year after the atoll-wide eradication operation.

sampling on Rimatuu



Yellow Crazy Ant Eradication

Principal Investigators:
Jayna DeVore, Simon Ducatez, Milena Philip
Affiliations:
Universite de Polynesie Francaise
French National Institute for Sustainable Development
Project Dates: August 2022 – Ongoing

In this project funded by the OFB, the Tetiaroa Society FP aims not only at eradicating the yellow crazy ant from Tetiaroa, but also at testing methodologies that will then be available for other islands of the region.

The yellow-crazy ant (*Anoplolepis gracilipes*, YCA) is one the 100 worst invasive species in the World according to the IUCN (International Union for the Conservation of Nature). By reaching very high densities and spraying formic acid at any animal on their path, yellow-crazy ants decimate native fauna.

In this project funded by the OFB, the Tetiaroa Society FP aims not only at eradicating the yellow crazy ant from Tetiaroa, but also at testing methodologies that will then be available for other islands of the region (e.g., YCA are now present in all five archipelagoes of French Polynesia, though no successful eradications have been conducted in the region so far). Mapping of the YCA across the atoll and the first baiting tests were carried out in 2022.

This first baiting test had a very strong effect on ants and presented limited undesirable effects on land crabs. So beginning in 2023 we implemented the yellow crazy ant eradication protocol to all invaded areas of the atoll. Baiting was carried out where ants were detected on Motu Onetahi, A'ie, Tiaraunu, and Horoatera by teams of up to 10 volunteers. At the same time, continuous monitoring of the effects of the baiting and of the ant eradication was carried out. By the end of the year monitoring showed the success of the treatments, with ant populations decreasing drastically (>95% reduction) after the first spreading, and no ants being detected in the plots monitored after the second baiting. Monitoring also showed a significant increase (X2) in the number of nesting brown noddies in plots that were deserted by noddies when the ants were present.

Coral Reef & Lagoon

Principal Investigators:
Hannah Epstein and Casey Benkwitt
Affiliations:
University of Lancaster, University of Essex
Project Dates: January 2021 – long term

The objective of this research is to assess the impacts of rat eradication and the subsequent return of healthy seabird populations on the health of the adjacent reefs on Tetiaroa.

The objective of this research is to assess the impacts of rat eradication and the subsequent return of healthy seabird populations on the health of the adjacent reefs on Tetiaroa. To find causal links across the lands-sea interface we are tracking how benthic (e.g., sediment, coral and algae) and pelagic (e.g., fish) assemblages and their ecology change throughout the rat eradication that Tetiaroa underwent in 2022. This holistic sampling approach allows us to characterize the environment in which reef organisms are living and assess both shifts in and impacts of nutrient cycling as a result of rat eradication.

In 2023 our team sampled in late November to early December (photos below). At a year and a half post-eradication, and with noticeable changes in bird populations (e.g., observations of ground nesting birds on Rimatuu), this time point provides a useful comparison to our pre-eradication data and at 6-months post eradication (November 2022). One major outcome from this trip is the continuation of our algae sampling around the entire atoll lagoon. We now have data from November 2021, 2022, and 2023, which will be used to create detailed maps of nutrient flows to coral reefs before and after the rat eradication.

In 2023 we also focused on analyzing a complex data set that includes data from across the TARP group (seabirds, algae, benthic community, fish, and water and coral microbes). This data, collected before rat eradication allows us to compare motu and nearshore environments that are historically rat free (Motu Aie), recently rat free (Reiono), and occupied by rats (Rimatuu). This work should allow us to develop a framework to evaluate the effect of island/coral reef restoration on short and long-term outcomes.

Seascape Ecology

Principal Investigators:
Lisa Wedding, Courtney Stuart, Pirta Palola
Affiliations:
Oxford University
Project Dates: September 2023

In 2023 two PhD students completed fieldwork for the Seascape Ecology project. Courtney Stuart studies nutrient cycling across the land-sea interface in Teti'aroa using a combination of landscape ecology theory, stable isotope analysis, and GIS-based approaches. During her September 2023 fieldwork in Teti'aroa, she collected samples of brown and green algae (*Turbinaria* and *Halimeda*). The samples were weighed to estimate wet biomass and then dried and ground in preparation for subsequent laboratory analysis of nutrient content and stable nitrogen isotopes. Ecological transect surveys of benthic cover and fish communities also complemented Courtney's algae sampling.

Pirta Palola is focused on marine remote sensing. During her fieldwork at Teti'aroa, she conducted hyperspectral radiometric measurements of benthic and surface reflectance. Additionally, she measured water quality parameters such as chlorophyll-a concentration, turbidity, and absorption coefficients of phytoplankton and non-algal particulate matter. Understanding the coral spectral signatures and the water column optical properties allows for an accurate correction between reflectance from the benthos and the water column. Hence, this data forms the basis for the physics-based remote sensing model for mapping land-sea connectivity and seascape spatial patterns at Teti'aroa.

Plant Surveys

Principal investigator :
Jean-Yves Hiro Meyer
Affiliation :
Délégation à la Recherche
Université de la Polynésie française
Project dates : January 2021-long term

The preliminary results show that vegetation response to rat eradication may vary according to the ecological characteristics of motus, especially their initial plant composition (e.g. no coconut plantation in Ahuroa) and the importance of long term monitoring.

This project focuses on the effect of rat eradication on forest dynamics. Annual monitoring of seedlings, recruitment of native woody species, and percentage of herbaceous plant cover were started on Motu Reiono and Motu Ahuroa in 2018 and 2021 Sampling is conducted along twenty 25 m long transects representing 1,000 one square meter quadrats.

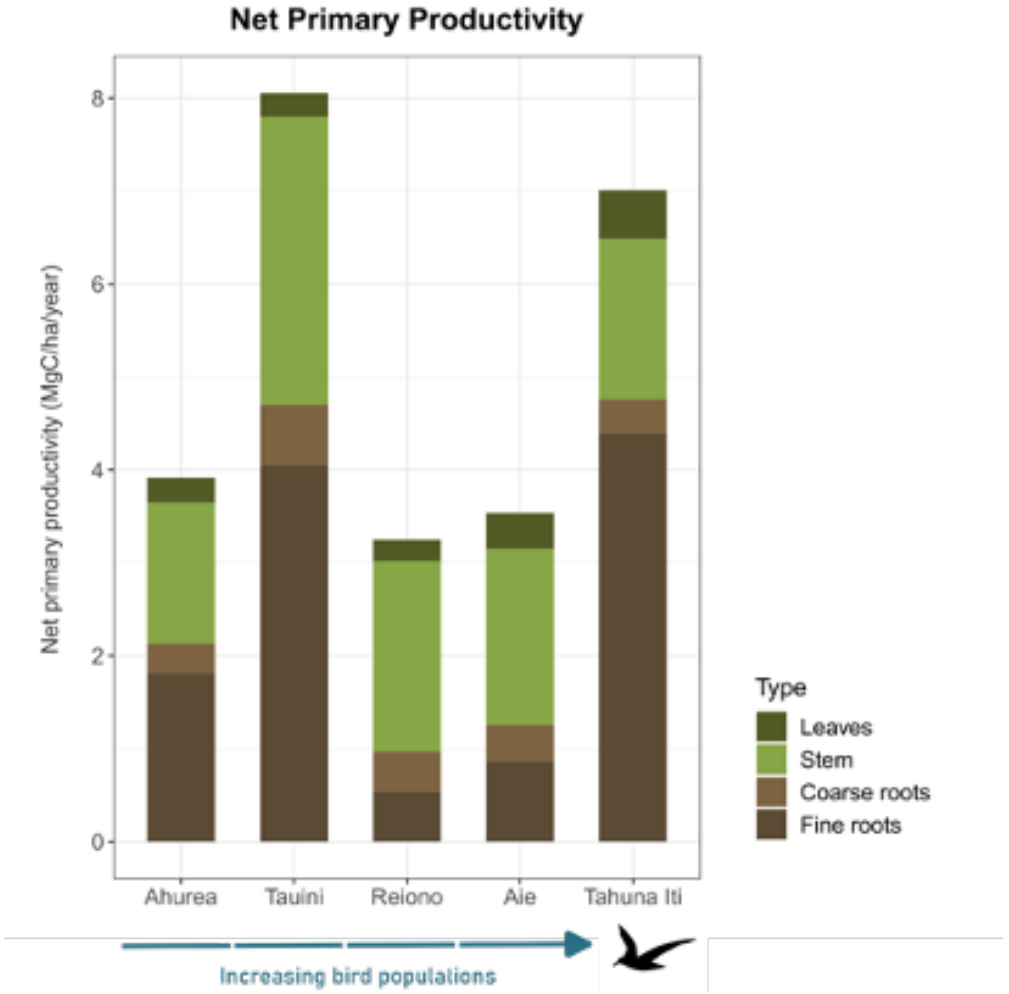
This work has revealed:

1. a slow decrease of *Pisonia grandis* seedlings with time in both motus;
2. an increase of *Cocos nucifera* seedlings in Reiono but not in Ahuroa ;
3. a strong increase of *Pandanus tectorius* and *Guettarda speciosa* seedlings, especially in Ahuroa ;
4. an increase of the cover of herbaceous plant (*Boerhavia tetrandra* in Reiono, *Portulaca oleracea* in Ahuroa), and native ferns (*Asplenius nidus* and *Microsorum grossum*);
5. the role and importance of natural disturbances (high swells, tree fall gaps caused by strong winds) in seed germination and seedlings survival during several years of monitoring.

In 2023, five new 25 m long transects were set up on Motu 'A'ie and surveyed to assess the effects of the Yellow Crazy Ant Anoplolepis gracilipes eradication. This will continue in 2024 to record any changes in vegetation dynamics.

Forest Ecology

Principal Investigator:
Yadvinder Mahli
Affiliation:
Oxford University
Project Dates: April 2021 – August 2024



Our Tahiti-based research assistant Solène Fabre has continued routine visits and collection of samples from litter traps and root ingrowth cores on Tetiaroa (together with intern Julie Andre), giving us over a year of the first ever data on forest productivity from tropical atolls (Figure 1). A striking discovery has been the very high root productivity observed on some atolls - we think this is the highest root activity ever observed in a tropical forest anywhere on Earth and are trying to puzzle out the reasons behind this.

These data will be combined with nutrient analysis, currently being run through the Oxford lab, to quantify nutrient cycling in bird-rich and bird-poor islands. The routine visits and data collection by Solène will continue until August 2024.

Arthropod Survey and Taxonomy

Principal Investigator:
Sebastian Steibl
Affiliations:
University of California, Berkeley
University of Auckland
Project Dates: July 2021 – Ongoing

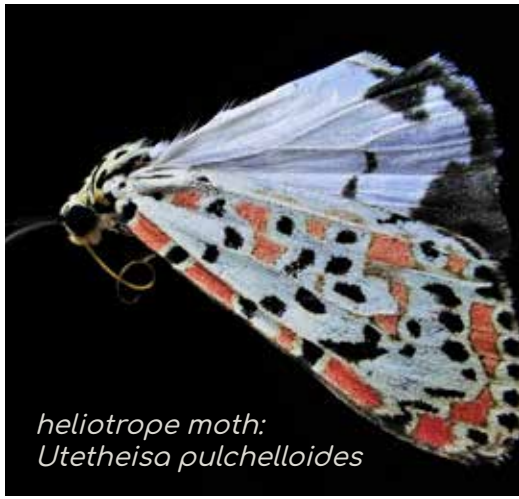
Understanding the response of insects to ecological restoration actions such as invasive species eradication is therefore key to generate conservation evidence on a functional system level.


Melanacanthus margineguttatus

Insects are an integral part of every terrestrial ecosystem including atolls. Insects pollinate plants, recycle nutrients, decompose decaying material, and form the basis of the food web. Understanding the response of insects to ecological restoration actions such as invasive species eradication is therefore key to generate conservation evidence on a functional system level. Since 2021, one-and-a-half years prior to the Tetiaroa rat eradication, we have been monitoring the insect community on all twelve motus of Tetiaroa atoll twice per year. In 2023, we completed another two atoll-wide sampling campaigns, adding to a large multi-year research dataset that will allow us to uncover systemic changes at an unprecedented level.

Additionally, in September 2023, we invited Dr Samuel Brown (Rangahau Ahumara Kai Plant & Food Research, NZ), a leading expert on Pacific beetles, to Tetiaroa atoll.

During a one-week fieldwork trip, Dr Brown and Dr Steibl discovered at least three undescribed species of weevil beetles on Tetiaroa atoll. The discovery of species that were unknown to science underlines the unique ecological value of Tetiaroa.


heliotrope moth: Utetheisa pulchelloides


dragonfly: Ischnura aurora


weevil: Acicnemis variegatus

Arthropod photos: Sebastian Steibl

Land crab population monitoring

Principal Investigators:
Jayna DeVore, Simon Ducatez,
Charlotte Bondoux, Mathilde Hernot
Affiliations:
Université de Polynésie Française
French National Institute for Sustainable Development
Project Dates: October 2022 – August 2023

We conducted a set of studies aiming at determining the consequences of rat and ant eradication on land crabs, and at deciphering how habitat affects crab responses. Between June and August 2023 we deployed 40 camera traps to monitor ghost crab (*Ocypode ceratolphthalma*) activity inland all around the atoll.

The same deployment was carried out before, during and immediately after the rat eradication, and this monitoring will therefore make it possible to measure the response of the crab community to the removal of the rats in the short, medium and long term.

In parallel, we detected a substantial increase in fiddler crab (*Paraleptuca crassipes*) activity in the hoa between Tiaraunu and Tauini, and the hoa between Hiranae and Oroatera – a species that we had only detected occasionally and in very small numbers before the 2022 eradication. This increase, already detected at the end of 2022, was confirmed across 2023 thanks to simultaneous crab counts conducted along the 35 km of coastal transects that we monitored for seabirds every three months.

We also characterized variation in behavioral traits in hermit crabs, both in the field and in captivity, using protocols that were already used before the eradication, to characterize any eventual changes in behavior following the eradication. The traits measured included boldness and exploratory behavior and involved more than 90 crabs from the different motu.

Finally, we conducted an in-depth investigation of how tupa (*Cardisoma carnifex*) select and transform their habitat. To that aim, we characterized the tupa burrow density, substrate and vegetation of 51 sites (each site including 3 to 4 quadrates of 5 km²) pseudo-randomly selected from across the atoll, 8 to 12 months after the rat eradication. We also investigated how tupa surface activity varies across time and habitats and measured the effect of tupa burrow density on leaf consumption

Coconut crab population survey

Birgus latro

Principal Investigators:
Dr. Gaspar Cécile, Dr. Dalleau Mayeul,
Dr. Gouin Jade, Guillaume Théo, Clervoy Romain
Affiliations:
Te Mana o Te Moana
Project Dates: October 2022 – October 2023

In this project we carried out a study to :
- continue the inventory of conconut crab individuals (size, sex, number) on three motu on the atoll of Tetiaroa : Honuea, Reiono and Tiaraunu
- specify the habitats according to their stage of development
- continue the statistical analysis to evaluate the population evolution over time
- evaluate the impact of rat eradication on the coconut crab population

Three sessions of coconut crab monitoring were carried out in 2022, 2023. Transects are done with coconut bait placed 10 meters away from each other. Bait are set up in the day and coconut crabs are counted during the night, along the transect. Sexes and thoracic length are recorded. For every monitoring session the same transects are used to compare the number of individuals.

Results of this study show new maximums concerning the number of individuals by transect in the 3 study sites and this number is increasing compared to previous study carried out by the organisation.

About thoracic length of coconut crabs :
- The rat eradication seems to have an impact on the size : there are more small individuals compared to study before eradication
- In average males are bigger than females

Females with eggs are observed with the highest proportion between December and January and have been observed between the 12th of November and the 26th of March. Moreover, the biggest individual ever observed in Tetiaroa before have been reported this year, with a thoracic length of 87 mm.
In future directions it would be interesting to study more the larval recruitment of this species to understand better their biological cycle.

Seabird population monitoring

Principal Investigators:
Jayna DeVore, Simon Ducatez, Antoine Vansse
Affiliations:
Université de Polynésie Française
French National Institute for Sustainable Development
Project Dates: July 2021 – ongoing

In February, May, August, and November of 2023 we carried out our quarterly monitoring of the seabirds of Tetiaroa. This monitoring, initiated in July 2021, makes it possible to assess the effects of the atoll restoration program on seabird populations. The number of nests, eggs, chicks, juveniles and adults of each species of bird is counted around the perimeter of each of the 11 motu (plus a small portion of Onetahi – the hotel area is excluded to avoid disturbing guests), as well as along interior transects in some motu (Tiaraunu, Tahuna Iti, Aie and Reiono). As a result, a total of approximately 35 km (divided into 100m transects) is covered each quarter. For each nest or roosting bird we also identify the species of tree used, with the aim of informing the Tetiaroa habitat restoration program. This has allowed us to quantify some clear habitat preferences; for example, of the 9,856 seabirds counted during one monitoring period, only 2.7% were nesting or roosting in coconut palm (one of the dominant vegetation types on Tetiaroa), indicating that coconut palm is poor nesting/roosting habitat for seabirds. This monitoring program also aims to quantify spatio-temporal variation in nutrient deposition by seabirds, via their guano, in order to inform the monitoring carried out on other compartments of the Tetiaroa ecosystems by other teams participating in the TARP program (e.g., coral microbiomes, algae composition, chemical signature of groundwater, etc.). This year this monitoring program allowed us to document some initial signs of seabird recovery following the rat eradication. For example, we detected a significant increase (x 2) in the number of white tern nests on motu previously invaded by rats – likely because white tern nests and eggs had a substantially higher survival once the rats were gone, increasing the number detected during our counts. It also allowed us to detect the first brown noddy nests in Oroatera and Tiaraunu. Although still anecdotal, these observations indicate that seabirds recovery/recolonization is already underway thanks to the rat eradication program.

Seabird breeding success monitoring

Gygis alba, Anous stolidus, Fregata ariel

Principal Investigators:
Simon Ducatez, Jayna DeVore, Sara Boucheron
Affiliations:
Université de Polynésie Française
French National Institute for Sustainable Development
Project Dates: January 2022 – ongoing

Lesser frigatebirds (Fregata ariel)

brown noddies (Anous stolidus)

The breeding success of brown noddies (*Anous stolidus*) and white terns (*Gygis alba*) was monitored using a combination of methods. This is our second year of data on brown noddy and white tern nesting success. From January to April, and from August and December 2023, camera traps were deployed on 6 motu to closely monitor the success of 40 white tern nests and 100 brown noddy nests, and to identify nest predators. In addition, 350 noddy nests were monitored weekly from January to April 2023 and 320 white tern nests were monitored every three weeks from January to May 2023. This monitoring allowed us to record an increased breeding success of brown noddies nesting in Aie as compared to the ones nesting in other motu, following the yellow-crazy ant eradication. It also provided detailed information on how nesting site selection (on the ground vs in trees, close to shore vs inland, etc.) affects hatching success and chick survival. These data will allow us to document any changes in nesting success associated with the yellow crazy ant (brown noddy) or rat (white tern) eradication programs.

white terns (Gygis alba)

We also installed two camera traps equipped with solar panels in Tauini in August, aimed at the colony of Lesser frigatebirds (*Fregata ariel*), before the start of their breeding season. These camera traps will stay in the field for one year while taking a photo every 30 minutes. These cameras will provide information on the development, breeding success and behavior of frigatebirds during one entire year without any disturbance to this sensitive colony.

White tern habitat selection *Gygis alba*

Principal Investigators:
Jayna DeVore, Simon Ducatez, Antoine Vansse
Affiliations:
Université de Polynésie Française
French National Institute for Sustainable Development
Project Dates: December 2022 – May 2023

Data from 460 nests revealed that both macro and micro scale elements are important for nesting site selection in this species, and that these elements can have consequence for nesting success.

We conducted an atoll-wide survey of the distribution of white tern eggs and chicks between December 2022 and May 2023 to determine what affects their nest site selection. Utilizing data collected along 52km of interior transects and 35km of coastal transects, this study was conducted at both the macro scale (importance of the type of forest, distance to the coastline, or rat/ant invasion history) and micro scale (importance of the tree species, branch height and branch length and orientation). Data from 460 nests revealed that both macro and micro scale elements are important for nesting site selection in this species, and that these elements can have consequence for nesting success. For example, branch thickness, slope, curvature, and angle to the dominant wind all affected the likelihood that an egg would survive to hatching.

Brown booby nesting success & ecology

Principal Investigators:
Beth Gardner, Sarah J. Converse, Jayna DeVore, Eve M Hallock, Amelia J. Duvall
Affilitations:
University of Washington
Université de Polynésie Française
Project Dates: January 2021 – long term

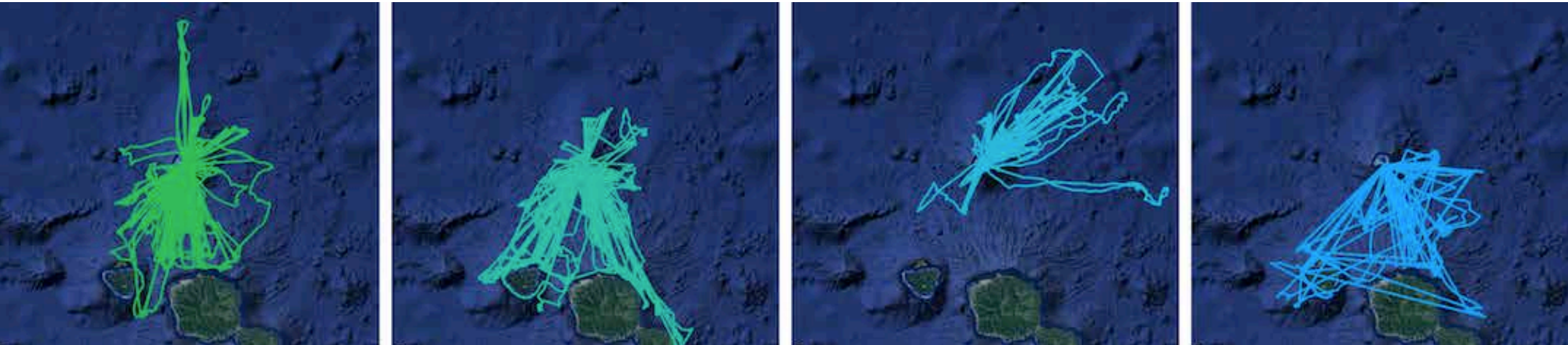
In 2023, we continued our work to better understand the ecology of seabirds at Tetiaroa in relation to removal of rats from the island. This incuded collecting data on nesting success, nest density, and activity of seabirds, long-term survival of seabirds, and foraging ecology of seabirds.

We collected data on nesting success of Brown Boobies for 6 months (January – June) using remotely triggered cameras and visual observations on 505 Brown Booby nests to determine the rate and, when possible, cause of nest failure. Data shows that storm swells and rats were the leading causes of nest failures prior to rat eradication.

To determine the relative activity of seabird species, we maintained 41 acoustic recorders that record audio each hour across the atoll. We banded 121 individual birds in order to provide long-term identifications and in October, we placed GPS tracking units on 12 Brown Boobies nesting on Tahuna Iti.

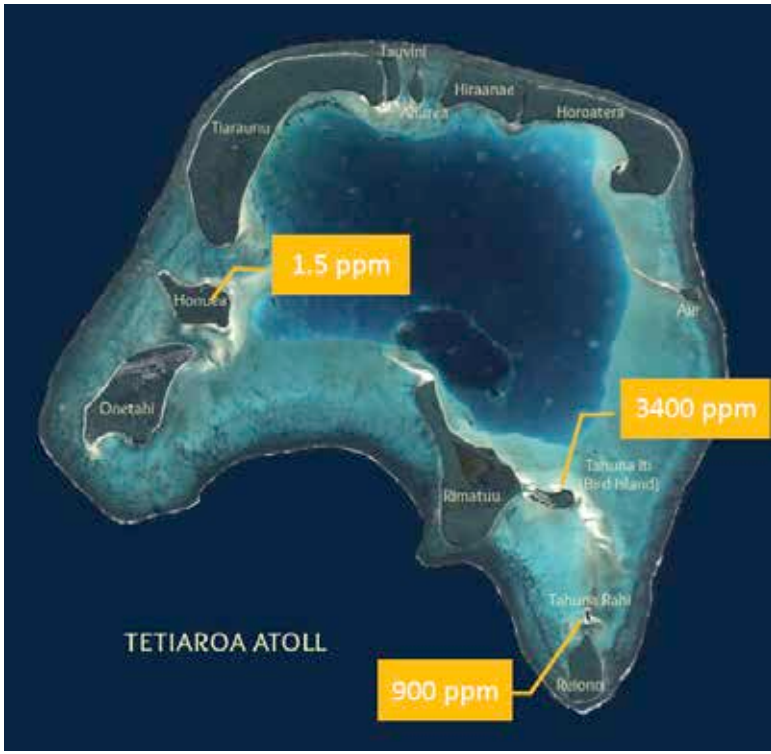
Figure 1: Two fledgling Brown Boobies resighted with colored leg bands on motu Tahuna Iti. (Photo credit: Eve Hallock)

Figure 2: GPS recorded tracks for 11 tagged Brown Boobies from October - December 2023 are shown, each panel is an individual bird. All individuals but one (78524C19) were recorded making southern trips to Moorea and/or Tahiti.



Groundwater Nutrient Transport on Atolls

Principal Investigators:
Matt Becker, Klaus Hagedorn
Affiliation:
California State University Long Beach
Project Dates: April 2023 – long term



Research this year showed that nitrate levels varied with bird populations and size of motu with very high levels on Tahuna Rahi and Iti as expected. We have also found geochemical conditions to be extremely stratified within the motu sediments with anoxic and denitrified conditions at very shallow depths below the water table.

Another accomplishment in 2023 was that we equipped current monitoring wells on Tahuna Iti, Honuea, Tahuna Rahi and Onetahi with real time water quality sensors to record - at an hourly frequency - changes in salinity, temperature and water level. These data could provide key information on the effects of seasonal weather changes and extreme events such as swells on the groundwater system. Our sensors could also provide useful data on the groundwater response to other, longer-term forcings such as rat eradication and bird population rebound, changing vegetation, etc.

In December we successfully drilled a 4 m deep boring through a substantial rock layer and set a monitoring well at 3 meter depth. This was done using a portable mud rotary drilling rig. This monitoring well will be used to sample water chemistry and level below the rock confining layer which we believe has a significant impact on water flow and nutrient flux to the reef.

Archaeological research on Teti'aroa

Princial investiagators:
Guillaume Molle, Vahine Ahuura Rurua, Gabrielle Traversat
Emilie Dotte-Saroout, Frédérique Valentin, Elisa Scorsini
Affiliations:
Centre International de Recherche Archaeologique sur la Polynesie
Australia National University
Project Dates: August 2017 – long term

Following a busy year in 2022 that saw the beginning of our excavation program, a large part of 2023 was dedicated to the lab-analyses of the material previously collected at two sites on Onetahi - one marae (temple) and a maite (agricultural trench pit).

Material collected from the marae which is under analysis include: marine shell assemblages, pig bones, thousands of fish bones, and charcoal. In late 2022 there was also a major discovery on the marae of an infant burial. Following strict professional protocol for working with human remains, and after consultation with the Tetiaroa Society Cultural Committee, the decision was made to do lab analysis on the bones. We were able to take samples to extract DNA and do chemical analysis, and also measure all of the bones. The DNA revealed that the child was female. Based on several bone measurements it was estimated that the age-at-death was between 1 and 2 yr-old with no indication of trauma or disease. A preliminary radiocarbon analysis returned a date of 271 +/- 18 BP, or mid-1700s. In May, 2023, a ceremony led by the TS Cultural Committee took place on Onetahi to rebury the child where she was discovered.

At the maite we were able to reconstruct the sequence of construction of the pit through microscopic studies. Additional phytoliths and charcoal analyses are planned in 2024 but a scientific paper is already in preparation and will report on this innovative study.

In 2023, the CIRAP team also secured a 4-yr funding grant from the Agence Nationale de la Recherche (France) for a project entitled PASTAtolls – Multidisciplinary approach to Polynesian Atolls Socio-Ecosystems in Time. Among the targeted atolls in this project is Teti'aroa and our team will continue the excavation program from 2024 onwards, including paleoenvironmental reconstructions and in-depth investigation of the dynamics between Polynesian and their terrestrial and marine ecosystems.

Mosquito Abatement

Principal Investigator:
Herve Bossin
Affiliations:
L'Institut Louis Malardé
The Brando
Tetiaroa Society

Tetiaroa AeLIMIN – An innovative strategy for the suppression of the Pacific tiger mosquito Ae. polynesiensis in Pacific island settings.

Over the past decade, Institut Louis Malardé has engaged in various field evaluation of innovative "Rear & Release" mosquito control strategies such as the Incompatible Insect Technique (release of Wolbachia-carrying male mosquitoes that sterilize their female counterpart in infested areas): from a limited-scale, feasibility trial on a motu of Raiatea to the largest field evaluation completed to date in French Polynesia on the atoll of Tetiaroa. An initial 12 months intervention was carried out in 2015-2016 which resulted in the successful suppression of Aedes polynesiensis on motu Onetahi (ca. 1 sq. km).

Preventative male mosquito releases have been performed since (except during the COVID crisis) to keep the mosquito nuisance at bay on the resort. Mosquito monitoring performed throughout the motu in 2023 indicates a successful suppression with only a few residual foci remaining.

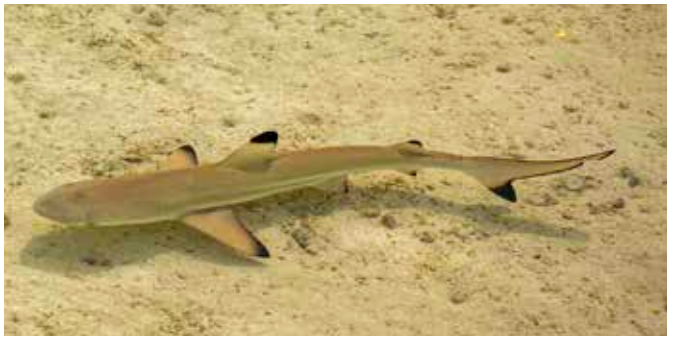
Planning by Tetiaroa Society and Institut Louis Malardé beagn in 2023 to prepare for a larger scale-deployment targeting mosquito elimination across the entire atoll in the years to come. This Tetiaroa Atoll Mosquito Elimination (TAME) project will contribute fundamental baseline data (including spatial mosquito population genomics analysis) and knowledge necessary to control mosquito populations at scale. Importantly, this will include outreach to the hotel guests and local communities including educational information about the challenges and opportunities of innovative mosquito control. The project will leverage ILM's new INNOVENTOMO male mosquito factory, an infrastructure unique in France and the Pacific, developed for the mass-rearing and release of sterile male mosquitoes to further explore the feasibility and sustainability of island-wide mosquito elimination.

Shark Population Ecology

Principal Investigator:
Aaron Wirsig
Affiliation:
University of Washington
Project Dates:
March 2014 – long term

The Tetiaroa Reef Shark Project reached a huge milestone in 2023 with its 10th year of operation (initiated in 2014)!

The year was also highly successful, with three major highlights. First, we completed two field seasons, during which we fully refurbished the receiver array and deployed 22 new tags across two species (Blacktip Reef Sharks and Sicklefin Lemon Sharks) and a wide range of sizes, from juveniles just weeks old (~ 50 cm) to near-adults approaching 2 m in length. This included 15 new state-of-the-art predation tags for small juvenile sharks which will tell us if/when these newborns are eaten by a larger shark. This information will be unprecedented, as predation rates on shark pups are largely unknown.

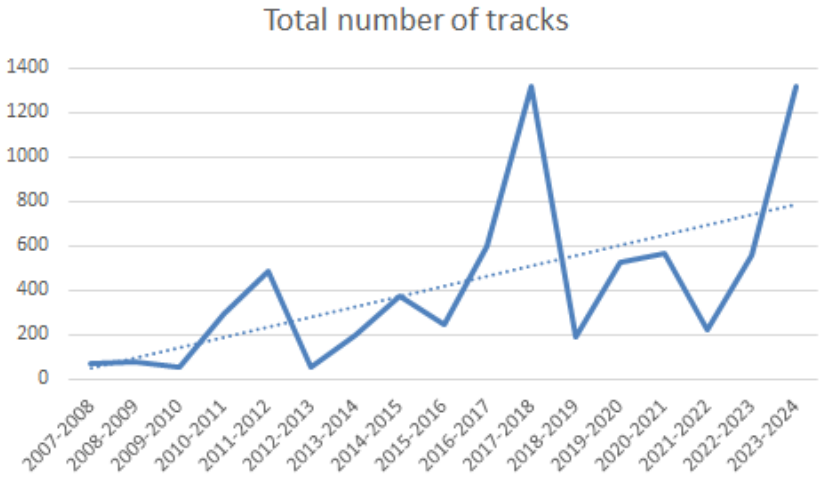


This year Fulbright fellow, Aarthi Kannan, continued her work on site recording shark behavior in the lagoon with baited remote underwater video systems (BRUVs). Aarthi collected hundreds of hours of video featuring sharks and many other atoll denizens that will now be used to shed new light on animal behavior in the lagoon, including when and where sharks are most active and whether sharks elicit avoidance by other fishes.

Green Sea Turtle Research

Principal Investigator:
Dr. Gaspar Cécile, Dr. Gouin Jade, Guillaume Théo, Clervoy Romain
Affiliations:
Association Te Mana o Te Moana
Project Dates: 2007 – Ongoing

Te Mana o Te Moana has monitored the nesting of green sea turtles on Tetiaroa atoll's beaches for 17 years. Over this time more than 7 000 tracks have been reported and more than 300 different females identified.



Nesting site surveys are done every year by our team, collecting data on: female identifications (photo-identification, tags on front flippers, genetic samples), nesting parameters, tracks monitoring, nest excavations (depth, incubation days, number of eggs laid, hatching success, embryonic development success, number of hatchlings, genetic samples) and the identification of predators. The study of climate change impacts is also carried out through the study of sex-ratio, erosion, and flooded nests.

During the 2022-2023 nesting season, 559 tracks have been reported including 154 nests. Onetahi was the most frequently visited motu compared to previous seasons where Horoatera or Tiaraunu were mostly visited. 30 different females have been identified: 4 of them have been identified in previous seasons.

The beginning of the 2023-2024 season seems to predict a high number of nests for this season. Currently, 1300 tracks are reported with 201 confirmed nests and 459 probable nests. 62 females are identified and 10 of them were recaptured from previous seasons. Due to different episodes of heavy swell, lots of flooded nests have been delocalised or submerged and there are big steps of erosion that have been created along some beaches where they come to lay their eggs.

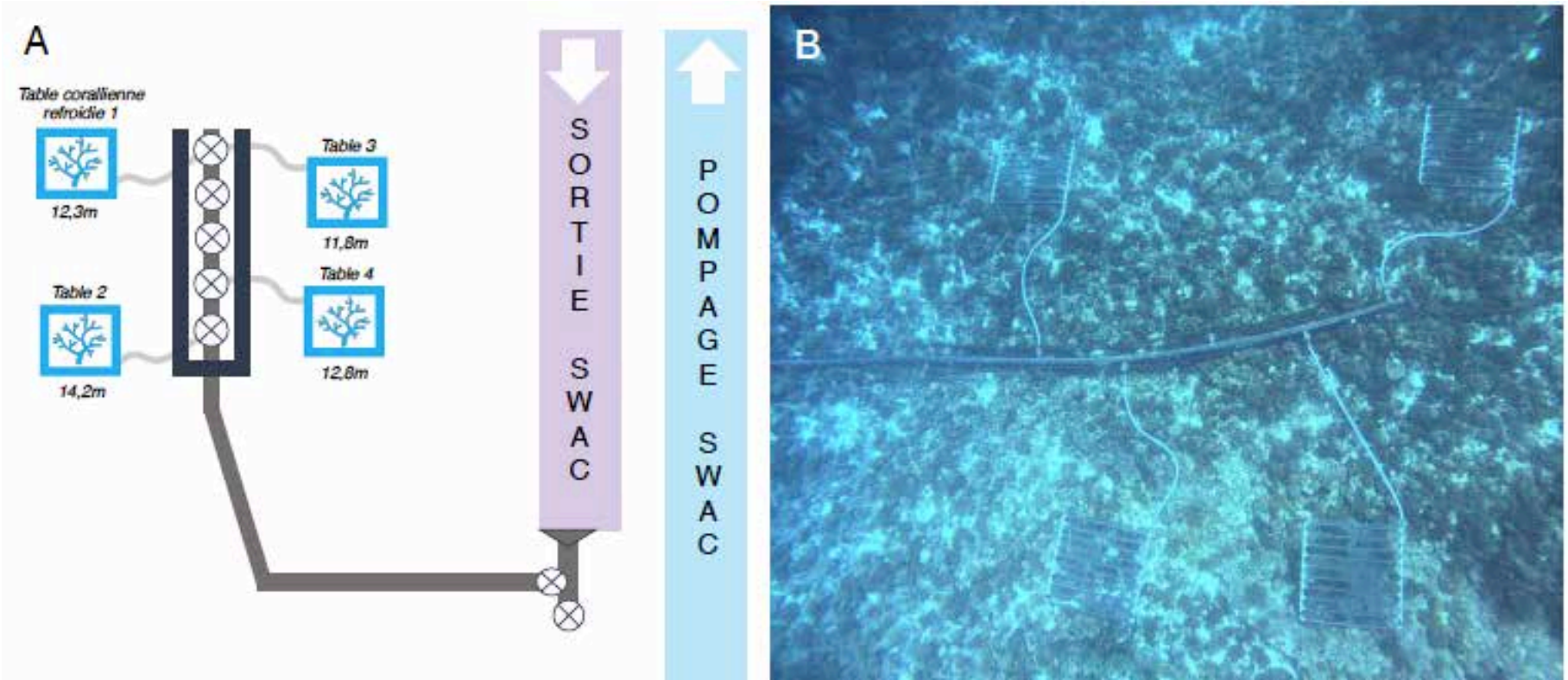
CoolReef

Coral reefs are showing the damage they are suffering from climate change every day and mainly due to ocean warming, which is the main cause of coral bleaching and resulting mortality.

Principal Investigators:
Serge Planes, Laetitia Hédouin
Affiliations:
Centre de Recherches Insulaires et Observatoire de l'Environnement
Project Dates: 2022-2024

Many initiatives are currently being discussed to promote the resilience of coral reefs in the face of climate change. The Cool Reef project has been developed to test the idea of cooling a section of the barrier reef using the cold outflow water of the Seawater Air-Conditioning (SWAC) system developed and used by Pacific Beachcomber (owners of The Brando resort). The SWAC pumps cold water up from 1000 meters to cool use for air-conditioning the resort, and then the outflow is returned to the ocean at depth.

In 2023 the Cool Reef Project tapped into the return pipe and diverted some of this water to a test site where experimental tables were set up. Small, perforated pipes released the cold water around the tables in order to cool the surrounding water. Temperature sensors were set up to monitor the temperatures over this test site. Late in the year recruitment plates were deployed to measure the settlement of juvenile coral. In 2024 the first live corals will be attached to the tables to begin growth observations.



Mapping Tetiaroa

Geographic Information System

Principal Investigator:
Benoit Stoll
Affiliation:
Université de la Polynésie Française
Project Dates: January 2017 – long term

In 2023 PhD student Tobias Ficher conducted 3 remote sensing operations in Tetiaroa: in March he worked mapping coastal geomorphology of the motu, then in May he worked to ground-truth the newest satellite image, and in July he worked with Jean-Yves Meyer to map vegetation.

Another graduate student working on her MA, Julie Daniellot-Dejoux, studied satellite images from 2014 to 2023 to determine changes in coastal geomorphology. She also worked with the TS Education Program to develop a field lesson plan on how to map beach profiles.

Tobias Ficher (PhD) and Julie Daniellot-Dejoux (master student)

3 students use the topometer in order to measure the beach profile on Onetahi (april 27 2023).

EDUCATION

The Tetiaroa Society Education Program hosts field courses with students from 8 yrs old to university level. Students that visit Tetiaroa learn about the unique natural and cultural heritage of the atoll, and the sustainable features of The Brando resort. In 2023 TS welcomed 132 local students and 60 students from the United States. These students came away from their experience on Tetiaroa with an incredible introduction to atoll natural history, and the rich cultural heritage of the island.

Local School Groups

Local schools that came this year included the Elementary Schools, Junior High, and the Université Polynésie Française. We also welcomed the Fraternité Chrétienne school that teaches disabled students and this was a remarkable experience for all involved.

Fraternité Chrétienne

Haapiti Primaire

Collège de Tipaerui

International School Groups

UC Berkeley Island Sustainability Program

Students from University of California Berkeley Island Sustainability class.

Richard Bailey, President of Tetiaroa Society, discusses sustainability programs on Tetiaroa with the UC Berkeley students.

Pacific Ridge Highschool

Eve Hall does a lecture for Pacific Ridge Highschool students

Lakeside Highschool

Lakeside Highschool students head off across the lagoon on an educational adventure.

Lakeside Highschool students do a beach cleanup project to see what the ocean deposits on Tetiaroa.

Master Students Projects

In 2023 the following five Master students completed their projects towards their degree on Tetiaroa. All were supervised by Simon Ducatez and Jayna DeVore through a joint program between University La Sorbonne in Paris and the Université de la Polynésie Française.

Antoine Vansse

Masters in Biodiversity, Ecology, and Evolution (National Museum of Natural History, Paris and Ecole Normal Supérieure, Lyon, France)
Site selection and nesting success of white terns (*Gygis alba*) on Tetiaroa Atoll.

Charlotte Bondoux

Masters in Biodiversity, Ecology, and Evolution; focus: Oceanic Insular Ecosystems (Université de la Polynésie Française, Tahiti and Université La Sorbonne, Paris)
Factors influencing ghost crab (*Ocypode ceratophthalmus*) activity and comparison of ghost crab abundance assessment methods in the context of a rat eradication.

Mathilde Hernot

Masters in Biodiversity, Ecology, and Evolution; focus: Ecological Modelling (Université de Rennes, France)
Factors influencing spatio-temporal variation in habitat use in the land crab (*Cardisoma carnifex*) on Tetiaroa atoll.

Sarah Boucheron

Masters in Biodiversity, Ecology, and Evolution; focus: Oceanic Insular Ecosystems (Université de la Polynésie Française, Tahiti and Université La Sorbonne, Paris)
Effects of breeding site selection and phenotypic variation on nest survival in the Brown Noddy (*Anous stolidus*).

Milena Philip

Masters in Biodiversity, Ecology, and Evolution; focus: Oceanic Insular Ecosystems (Université de la Polynésie Française, Tahiti and Université La Sorbonne, Paris)
Drivers of variation in yellow crazy ant (*Anoplolepis gracilipes*) abundance and impacts on native fauna in an atoll ecosystem.

COLLABORATIONS

The Nature Conservancy & American Bird Conservancy

In 2023 Tetiaroa Society joined a project with The American Bird Conservancy and The Nature Conservancy to develop guidelines for atoll restoration. This resulted in a successful grant proposal to the International Union for the Conservation of Nature to develop "*The Seabird Forest Toolkit: A Resource for Climate Adaptation Across Tropical Ocean Regions*." Work on this will begin in 2024.

Mission Blue Hope Spot

Tetiaroa Society continued its partnership with Mission Blue this year as one of their Hope Spots. MIssion Blue is developing support for a global network of marine reserves and Tetiaroa Society is proud to be a partner with them.

Fair Island Project

The FAIR Island Project is working with Tetiaroa Society to coordinate research on the island with an optimal data policy for open access, mandatory registration requirements, and data management plans containing controlled vocabularies and identifiers implementing global standards. All researchers working on Tetiaroa, resident or visiting, are required to create data management plans (DMPs) for their proposed projects to study the island and said DMPs are updated as data collection advances. The goal is to translate the broader FAIR principles into a set of specific requirements and implementable activities that demonstrate how good data management practices and policies accelerate research for the benefit of all stakeholders.

Global Impact

Blue Climate Initiative
Solutions for People, Ocean, Planet

The Blue Climate Initiative was born four years ago as an initiative of Tetiaroa Society to move beyond the borders of Tetiaroa and address the most important environmental issue humankind has faced: climate change. In response to an urgent need to stop Deep Sea Mining (DSM) before it starts, our work over the past year focused on a DSM moratorium.

This work was multifaceted and included:

1. Sponsoring a call by Indigenous leaders for a DSM ban, which has been signed so far by representatives of over 70 indigenous groups in 50 countries,
2. An exclusive presentation on the folly of DSM to a US Interagency Working Group organized by the White House,
3. Bringing the perspective of Indigenous Pacific islanders to the floor of the International Seabed Authority (ISA), and
4. Publishing an important and influential research paper debunking the mining industry's claim that DSM is necessary for the growing EV market and the green transition.

The Voice of the Ocean program, launched in 2022 brings together Indigenous leaders and communities to share their deep relationship and connection with the ocean, build a "rights of the ocean" movement from the Indigenous perspective, and assemble a powerful coalition of Indigenous communities for ocean protection. This year we brought this project to the IMPAC5 meeting in Vancouver in the form of a keynote speech by Hinano Murphy, and a symposium that featured indigenous leaders from across the Pacific and Canada.

Indigenous leaders from across the globe spoke out against Deep Sea Mining and signed the petition.

COMMUNITY

Tahiti Choir School

The Tahiti Choir School came to Tetiaroa this year to add their incredible harmonies to the sounds of the island. They sang the Tarava Teturoa (a traditional-style acapella song written by Hinano Murphy) out on the lagoon with only the birds and crabs for an audience, and some amazing traditional songs at sunset for the resort guests. This event seamlessly blended our commitments to education, traditional knowledge, and community involvement.

Government

Tetiaroa Society was honored to host a one-day event on the island and present our programs to an amazing group of government leaders.

This group included:
Moetai Brotherson – President of French Polynesia

Eliane Tevahitua – Vice-President of French Polynesia

Eric Spitz – Haut-Commissaire Polynesie Francaise

Hervé Berville – French Secretary of State for the Ocean and Biodiversity (Secrétaire d'Etat chargé de la Mer et de la Biodiversité)

Teura Iriti - Mayor of the Commune of Arue (which includes Tetiaroa)

Cultural Committee

The Tetiaroa Society Cultural Committee overseas all issues that require cultural expertise across our education, research, and conservation programs. This year once again their services were crucial to our commitment to the community that we ground our programs in Polynesian culture.

OPERATIONS

Personnel

In 2023 the expanding task of operating the organization lead us to create some additional positions.

The first change was that we created a new position of Director of Operations, and this was filled early in the year by Vairupe Huioutu-Pater.

By the end of the year, we added another position of Ecostation Manager, and this was filled by the former Head Ranger, Temakehu Murphy.

At the same time, Executive Director Frank Murphy moved to a new position as Director of Programs in order to focus more on program development.

On our Guide and Ranger teams some staff moved on to new adventures and we welcomed new faces to join us in our mission.

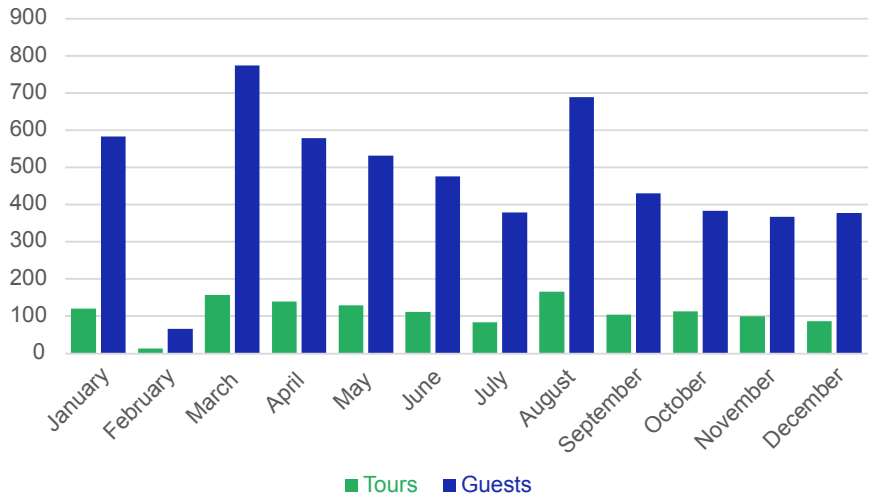
TS staff
Front left to right – Tihoni Maire (Head Guide), Hinano Teavai-Murphy (Cultural Director), Frank Murphy (Director of Programs), Vairupe Huioutu-Pater (Director of Operations), Temakehu Murphy (Ecostation Manager)
Back left to right – Teva Salmon (Guide), Tuterai APUARII (Ranger), Remi Conte (Guide), Manahau Pease (Guide), Luciano Kolokilagi (Ranger), Kealoha Wilkes (Guide)

Guide Program

Actions and Tour Numbers

Tours per month

	Tours	Guests
January	121	583
February	13	66
March	157	775
April	140	579
May	130	532
June	112	477
July	84	379
August	166	689
September	105	431
October	113	383
November	100	368
December	86	378
TOTALS	1327	5640



In 2023 the Guide Team once again worked hard to introduce The Brando resort guests to the wonders of Tetiaroa. New programs and presentations were also developed to teach guests about the natural and cultural history of the island. As always the Guides were the face of Tetiaroa Society and starred in promotional videos and publications and were wonderful representatives for our organization.

Guide Program

Other Activities

Creation of a Stargazing Tour

The tour presents the creation of the sky and the stars from the point of view of the Polynesians. and introduces the traditional knowledge of the celestial elements and their use in ocean navigation.

Earth Hours: Storytelling Night

Guests of The Brando listened to the 'Legend of the Creation of the World' under the stars.

World Ocean Day

Several groups of volunteers, along with staff of TS and The Brando,spent the day on the motu picking up trash that was brought in by the waves.

Ranger Program

The team and the work

The Tetiaroa Society Rangers have played a pivotal role in safeguarding the ecological integrity of Tetiaroa throughout the year 2023. Their tireless dedication and unwavering commitment to conservation have been evident in various aspects of their work, demonstrating a comprehensive approach to preserving Tetiaroa's natural heritage.

Throughout the year, the Rangers have been actively engaged in diverse activities aimed at protecting Tetiaroa's ecosystem. They kept conducting surveillance of the atoll, ensuring compliance with environmental regulations and promptly addressing any infractions. This included monitoring visitor activities, overseeing charters, and enforcing rules to safeguard sensitive habitats and wildlife. A significant shift has been observed this year with the notable decrease in fishing activities within the lagoon. Entire months have passed without any fishermen in the lagoon, a previously unheard-of occurrence.

In addition to their surveillance efforts, the Rangers have played a crucial role in supporting scientific research and conservation projects on Tetiaroa. They have assisted researchers in fieldwork, facilitated access to remote areas for data collection, and contributed to initiatives aimed at eradicating invasive species and restoring native habitats. Their involvement in projects such as rat and yellow crazy ant eradication underscores their proactive stance in mitigating threats to Tetiaroa's biodiversity.

Furthermore, the Rangers have been instrumental in the management and maintenance of Tetiaroa's eco-station facilities and equipment. Their dedication to ensuring the functionality and cleanliness of the eco-station has been exemplary.

Volunteers

Lending a hand

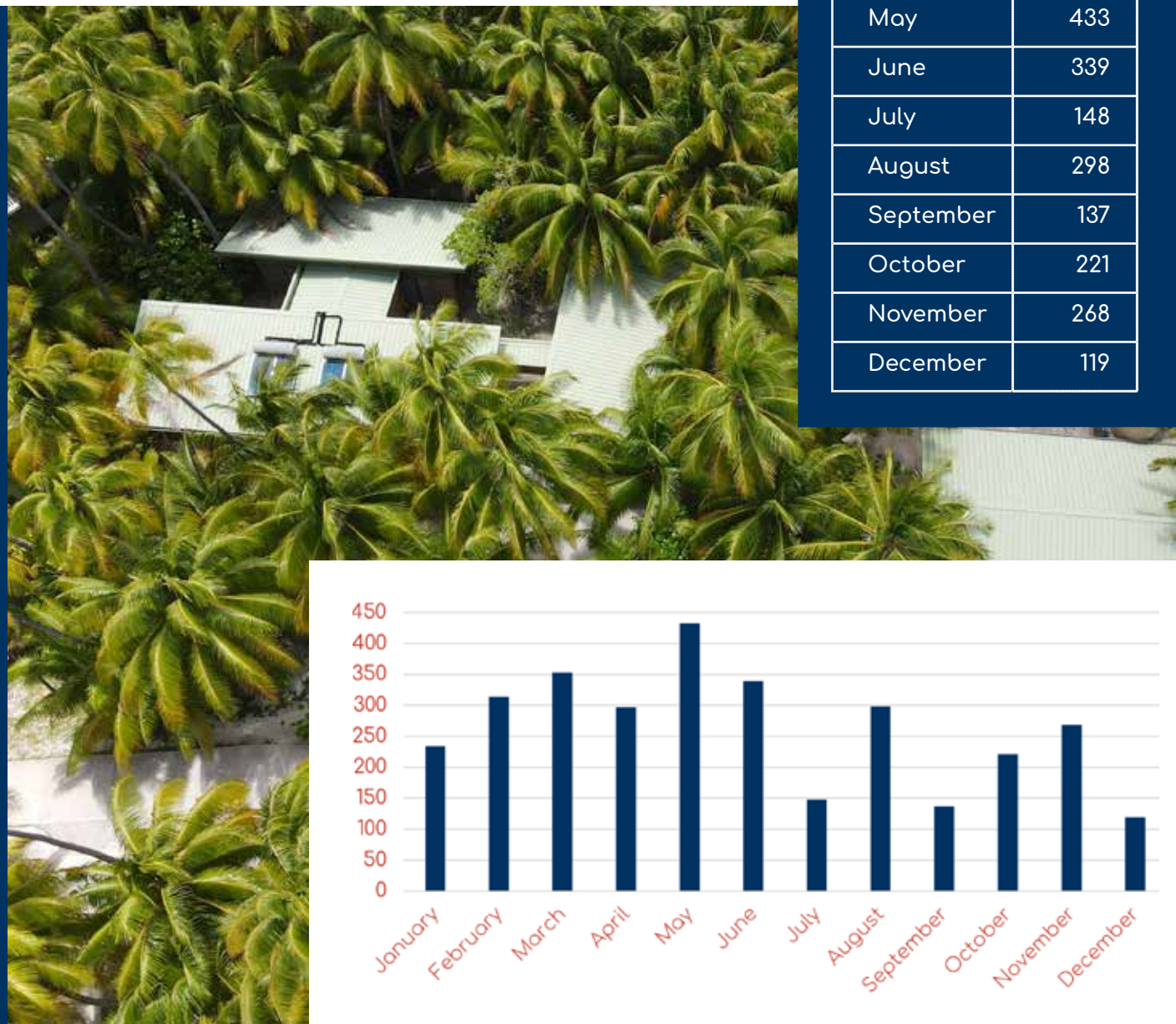
Volunteers have been crucial to the work we have done on Tetiaroa over the years. This year was no different, and as always people stepped up to help us with projects. The Yellow Crazy Ant Eradication program needed a dedicated group to help with bait distribution. We were able to bring back people who also came to help with the rat eradication work, and also a few new faces. Over course of the year this volunteer group put in weeks of hard work distributing bait through the vegetation of the motu.

We also get volunteers from The Brando staff who come out with field researchers on occasion or groups that volunteer for a day of beach clean-up.

Ecostation Use

The Tetiaroa Society Ecostation was very busy again this year, with projects that needed a lot of person power, field courses from around the islands and across the ocean, and large long-term projects. After two years of heavy use the decision was made to develop a plan to greatly expand the facilities. Work on that will start in 2024.

User Groups	User Days
TS Education Program	994
Universite Polynesie Francaise MA Program	705
TS Rat Team	560
TS Yellow Crazy Ant Team (Interns and Volunteers)	476
University of Washington	440
Institute Louis Malarde	311
TS Research Intern	246
Universite Polynesie Francaise Research	88
University of Auckland	63
Oxford University	56
California State University Long Beach	38
CRIOBE	24
Lancaster University	21
The Nature Conservancy	21
University California Santa Barbara	20
TOTAL	4063

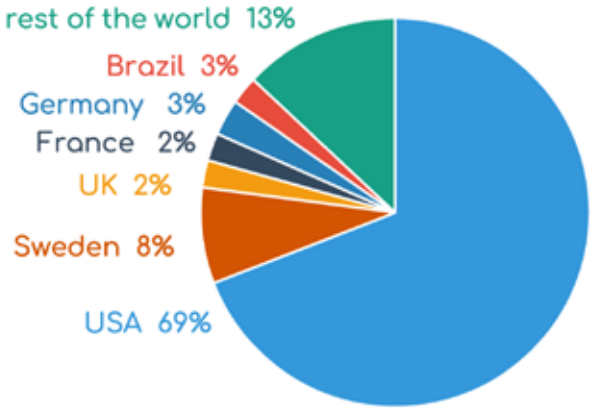


Month	User Days
January	234
February	314
March	353
April	297
May	433
June	339
July	148
August	298
September	137
October	221
November	268
December	119

Communications

Tetiaroa Society Communications rolled along this year. The website was migrated to Drupal 10, performance & styling upgrades were implemented throughout the year. Three well-received newsletters were sent out to our readers, and social media posts increased in frequency when the guides took on the role of social media posters. Internal communications improved with the use of Workspace shared drives and Microsoft office apps being made available to TS staff.

Newsletters "News from the Atoll"



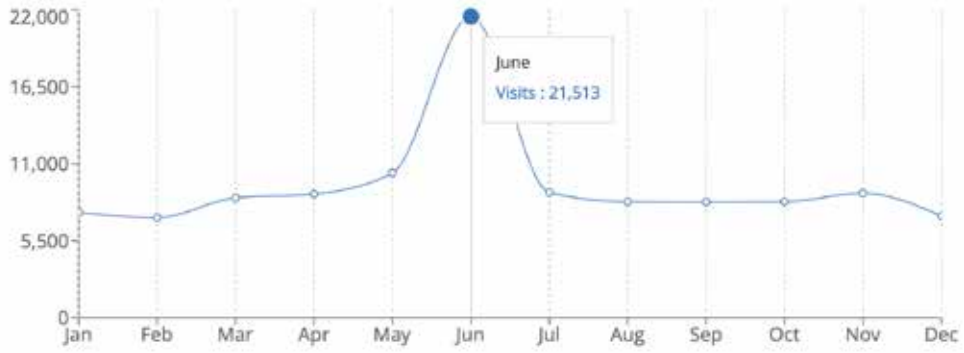
Tetiaroa Society sent 15,478 newsletters during 2023, with an open rate of 58%. "News from the Atoll" has 4129 subscribers, of which 42% are considered 'highly engaged' (they open the newsletter and click links).

Social Media

Tetiaroa Society has 5.7K followers and a 5-star rating on facebook. With posts in English and French, our message is reaching a diverse audience.

Communications via Website

Site Visits 2023



Pages Served

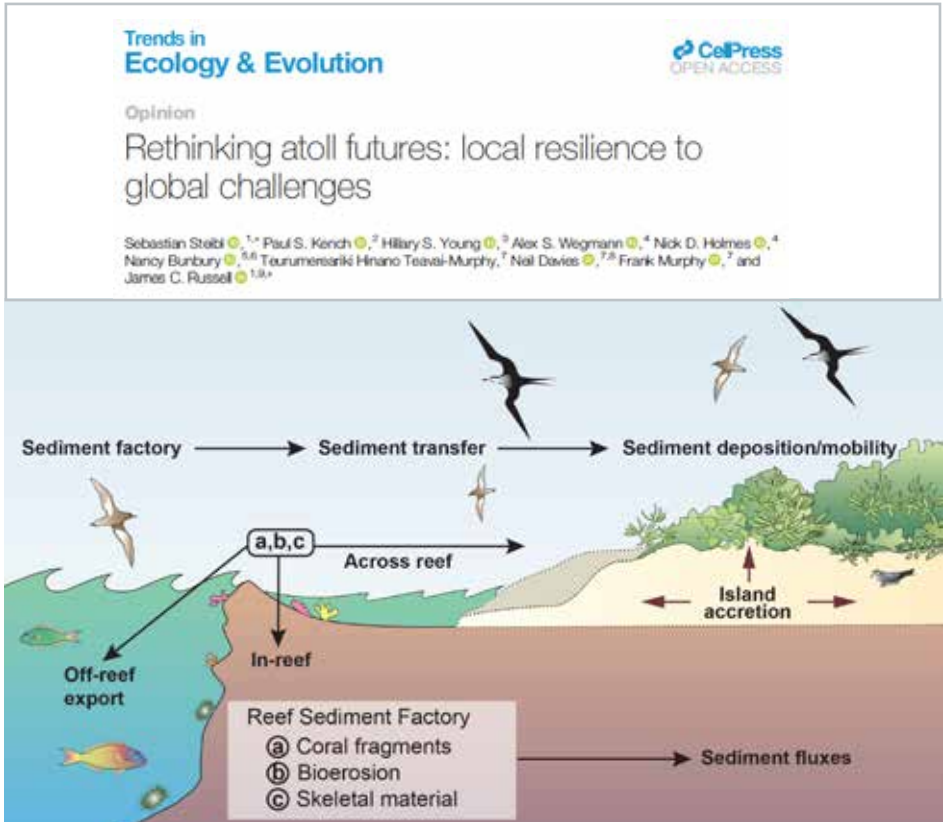
Publications and Presentations

An article in the magazine "*Outre-Mer Grandeur Nature*" featured the Yellow Crazy Ant Eradication Project.

UN PROJET EXPÉRIMENTAL POUR ÉRADIQUER LA FOURMI FOLLE JAUNE EN POLYNÉSIE FRANÇAISE

L'association Tetiaroa Society, lauréate de l'appel à projets MobBiodiv' lancé par l'OFB en 2021, mène un projet d'éradication de l'une des 100 espèces exotiques envahissantes les plus problématiques pour la biodiversité au niveau mondial [1] : la fourmi folle jaune. S'il s'avère satisfaisant, le protocole expérimental testé pourrait à terme être répliqué sur d'autres territoires.

This year Jayna DeVore and Simon Ducatez presented results of their work at the annual meeting of the Ecological Society of America (ESA), the largest gathering of ecologists in the world, and at the International Island Biology Conference (IBC) in Lipari, Italy, the international conference gathering specialists in island conservation and ecology from across the world.

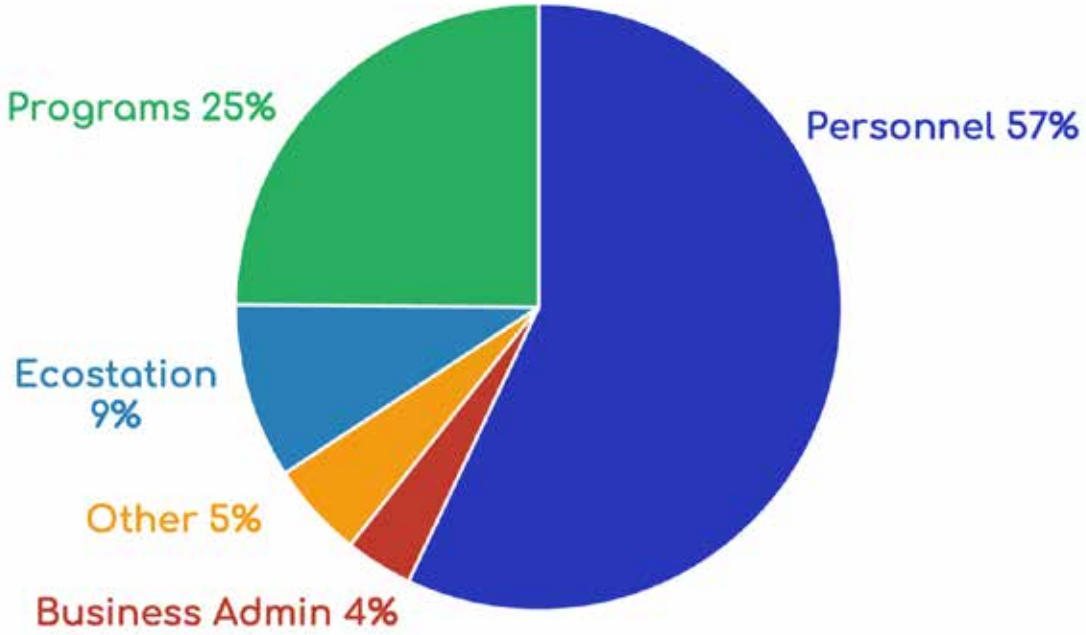


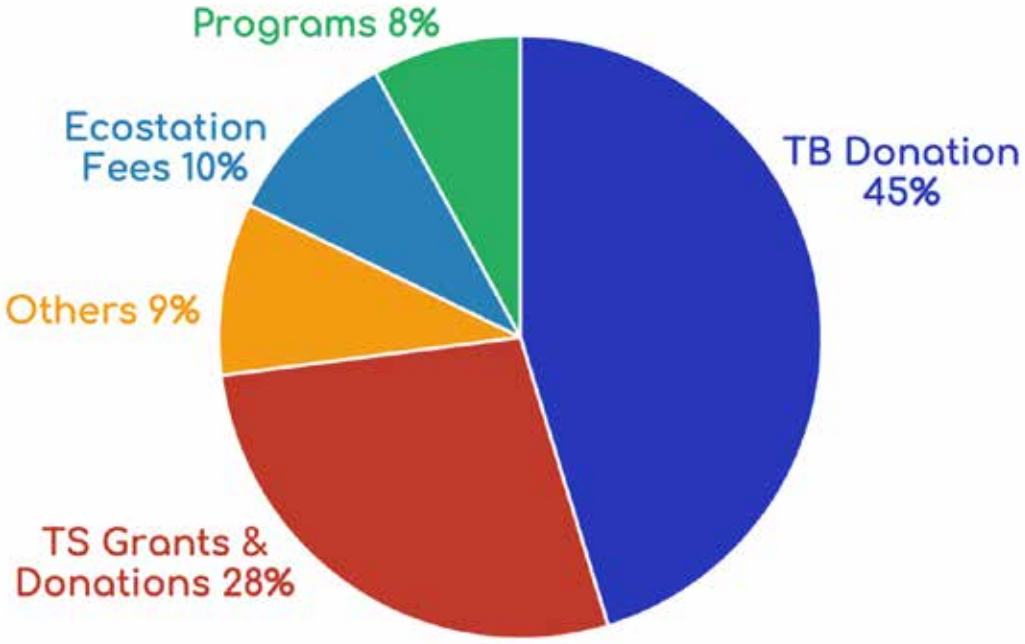
In December of this year Hinano Teavai-Murphy, Frank Murphy, and Neil Davies were co-authors on an important publication that makes the argument that atolls can be restored to a natural state and that this will make them resilient to climate change. The principal author Sebastian Steibl combined his experience working on Tetiaroa with observations from other atolls including Palymra and Aldabra. Authors on the paper represented many institutions including University of Auckland, National University of Singapore, University of California, The Nature Conservancy, Seychelles Islands Foundation, University of Exeter, University of Aberdeen.

Expenses & Income

Expense category	Amount USD
Personnel	$567,642
Ecostation	$92,852
Business Admin	$35,852
Programs	$247,501
Other	$50,807
TOTAL	$994,654

Income source	Amount USD
TB Donation	$420,792
TS Grants & Donations	$257,180
Ecostation Fees	$90,939
Programs	$74,210
Other	$85,210
TOTAL	$929,042





Donations

Donations are vital to the programs and mission of Tetiaroa Society. Without donations we could not do the important work we are engaged in.

We are fortunate that donations from The Brando pay for our core operations, but we need additional funds to achieve our objectives.

We deeply appreciate the support we received in 2023.

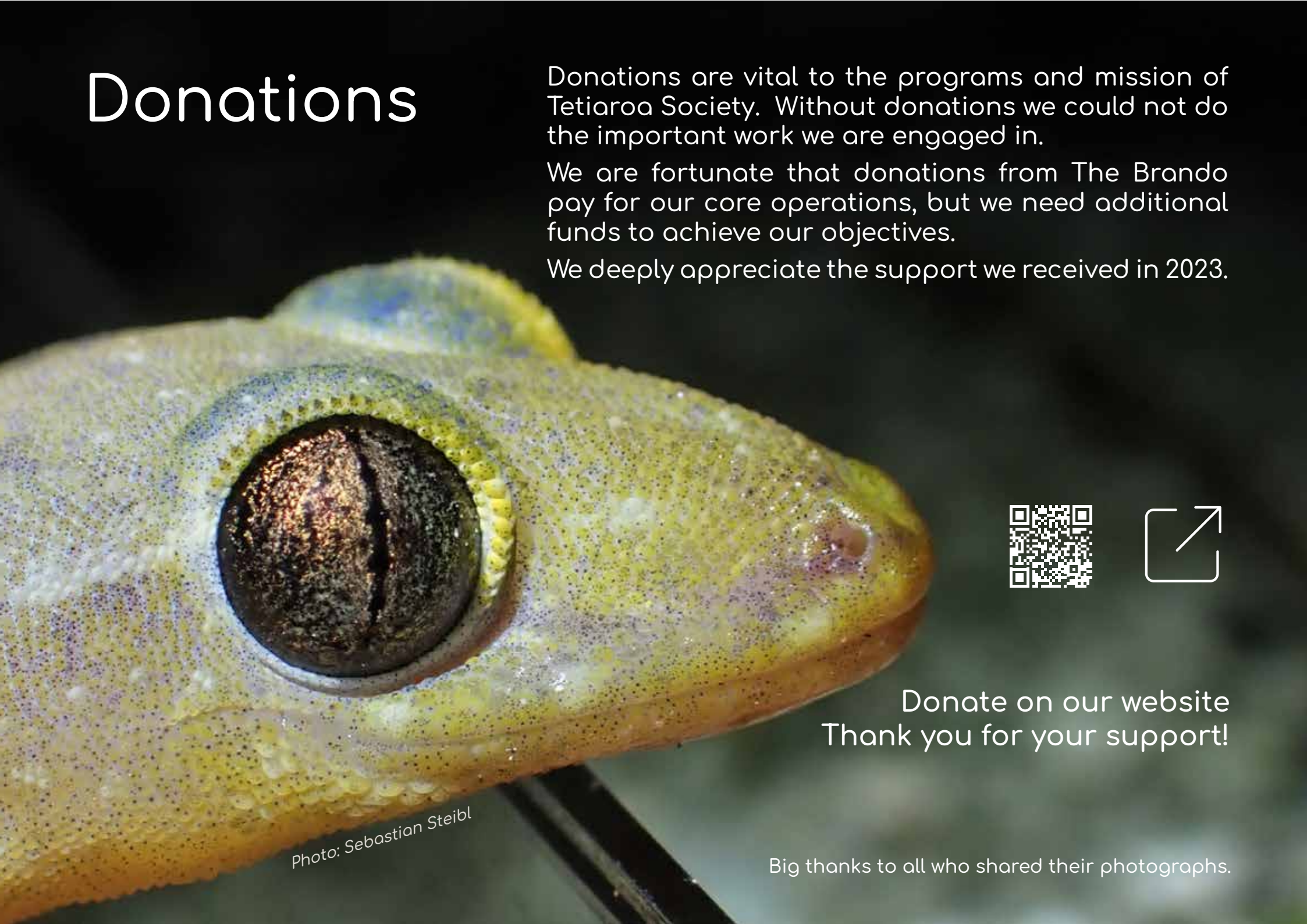


Photo: Sebastian Steibl

Donate on our website
Thank you for your support!

Big thanks to all who shared their photographs.

Partners

SUSTAINABILITY
COLLABORATION !